

Plague Control in Northern Arizona



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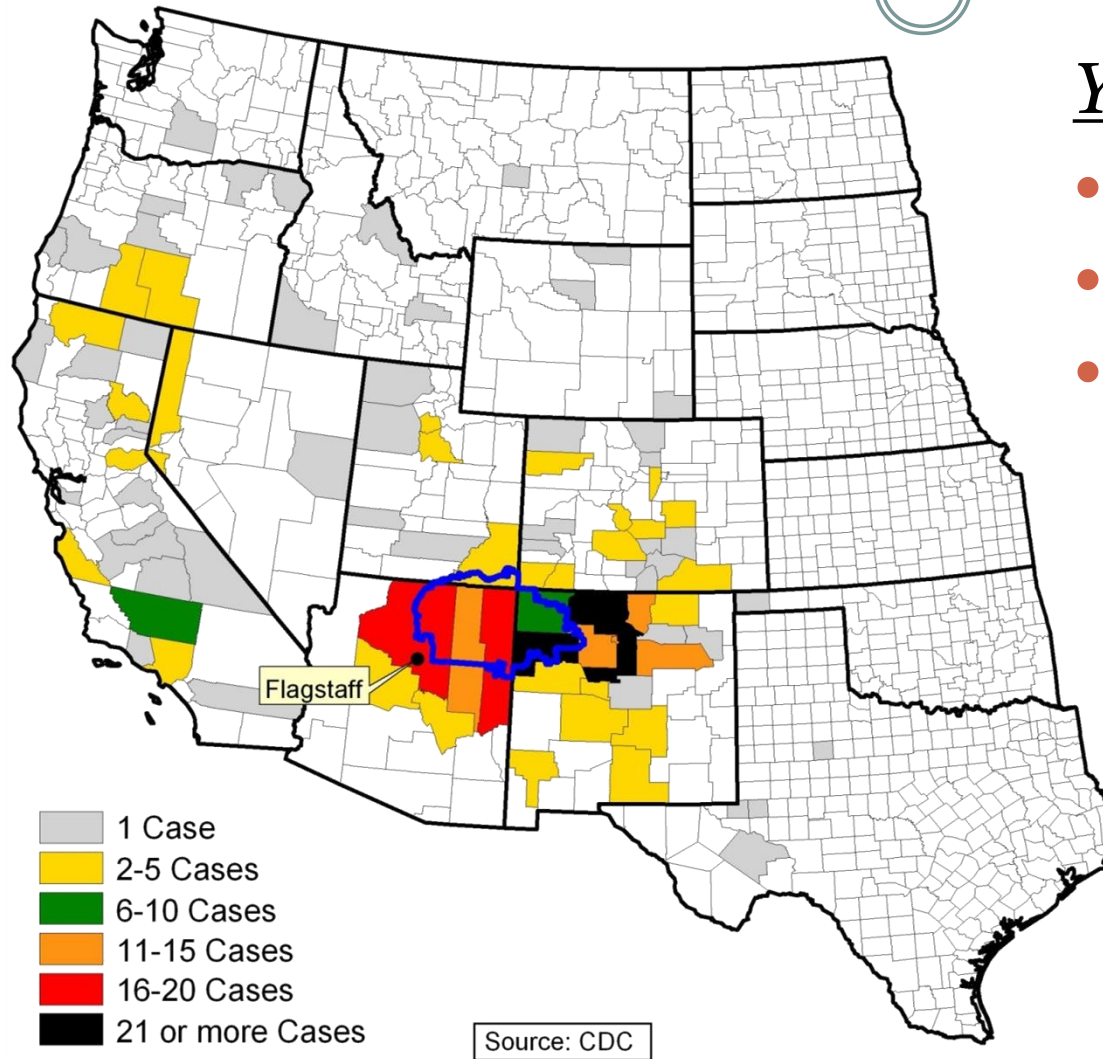


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NAU-MGGen (Center for Microbial Genetics and Genomics)
- BSL₃ Facility for bacterial pathogens

Human plague in the US: 1970-2000



Yersinia pestis

- Highly pathogenic
- Rapid clinical course
- High mortality if untreated

Three historical plague pandemics



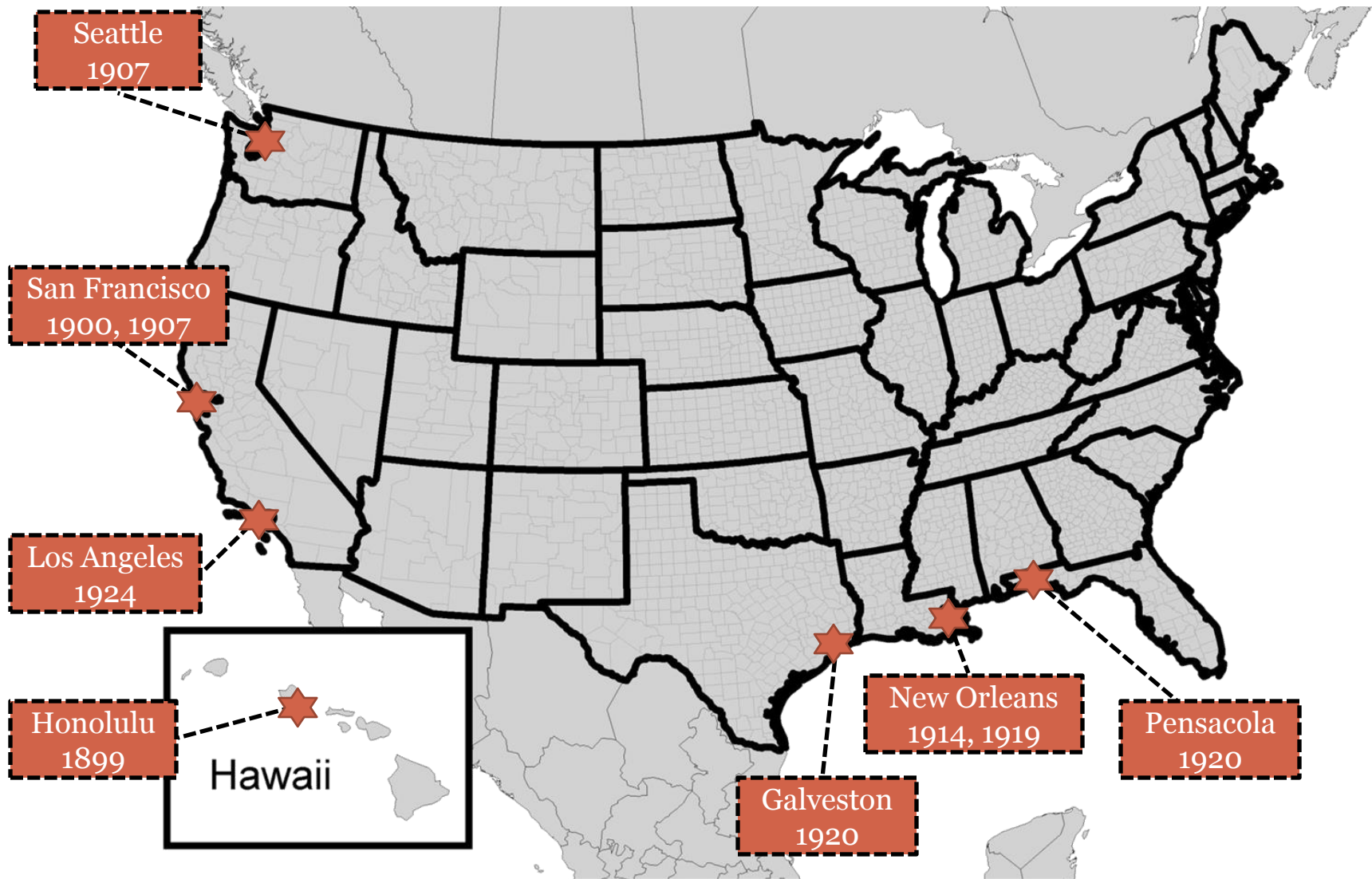
- 1st Pandemic: “Justinian plague”
 - 6th-8th centuries AD
 - Affected North Africa, Europe, parts of Asia
 - Population losses estimated at 50-60%
- 2nd Pandemic:
 - 14th-17th centuries AD
 - Affected North Africa, Europe, parts of Asia
 - Black Death epidemic: 1347-1351
 - ✦ Est. 17-28 million killed, or ~30-40% of the European population
- 3rd Pandemic:
 - 19th-20th centuries AD
 - Global spread out of China: Africa, Americas, Australia, Europe
 - Millions of deaths worldwide
 - Control: improved hygiene (rat control) and antibiotics

Rats (*Rattus* spp.) and their fleas were important hosts during global spread and establishment of plague foci in cities



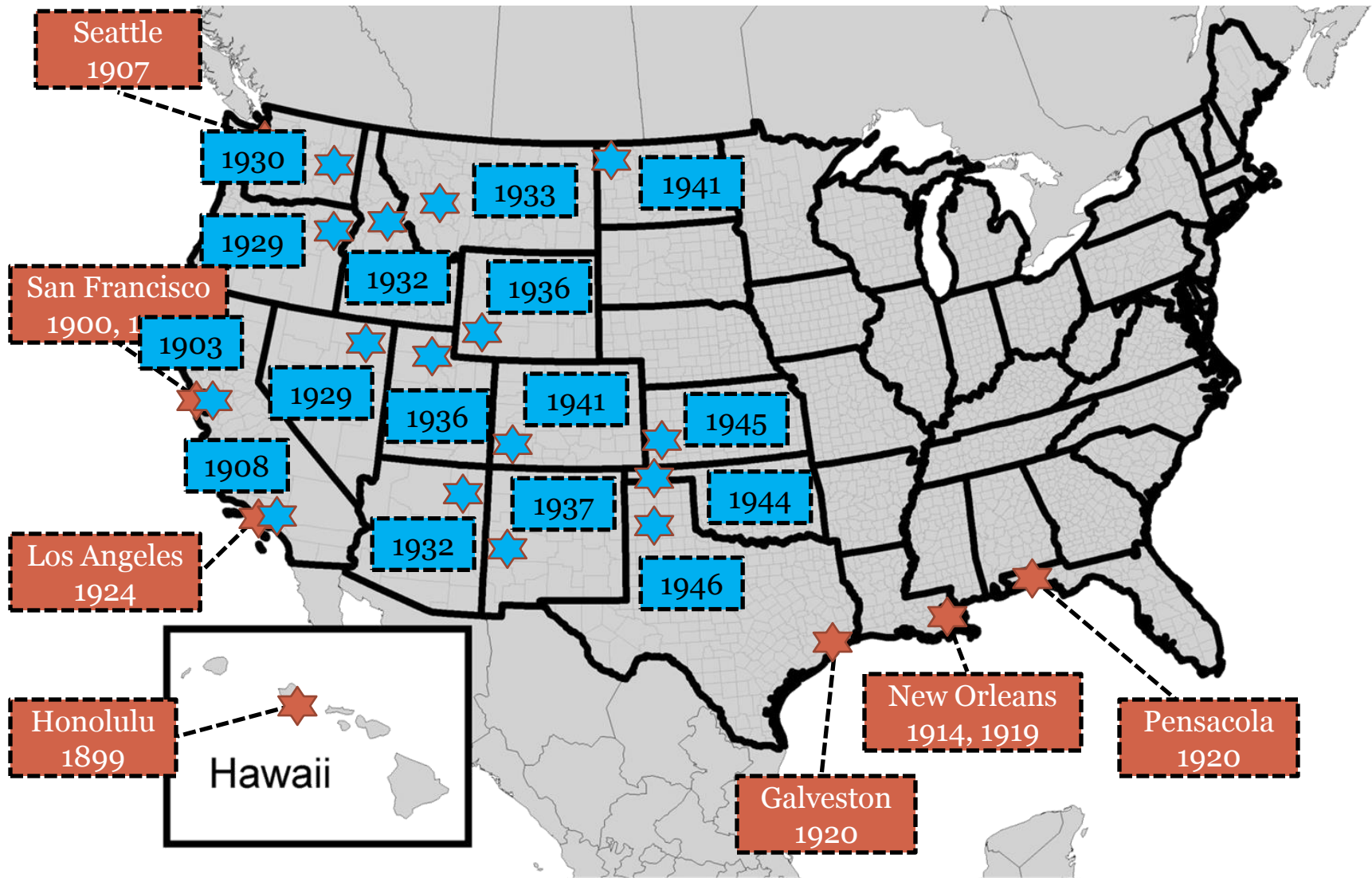
Rat in NYC, photo by David Shankbone

Rat-borne Plague in Multiple Port Cities



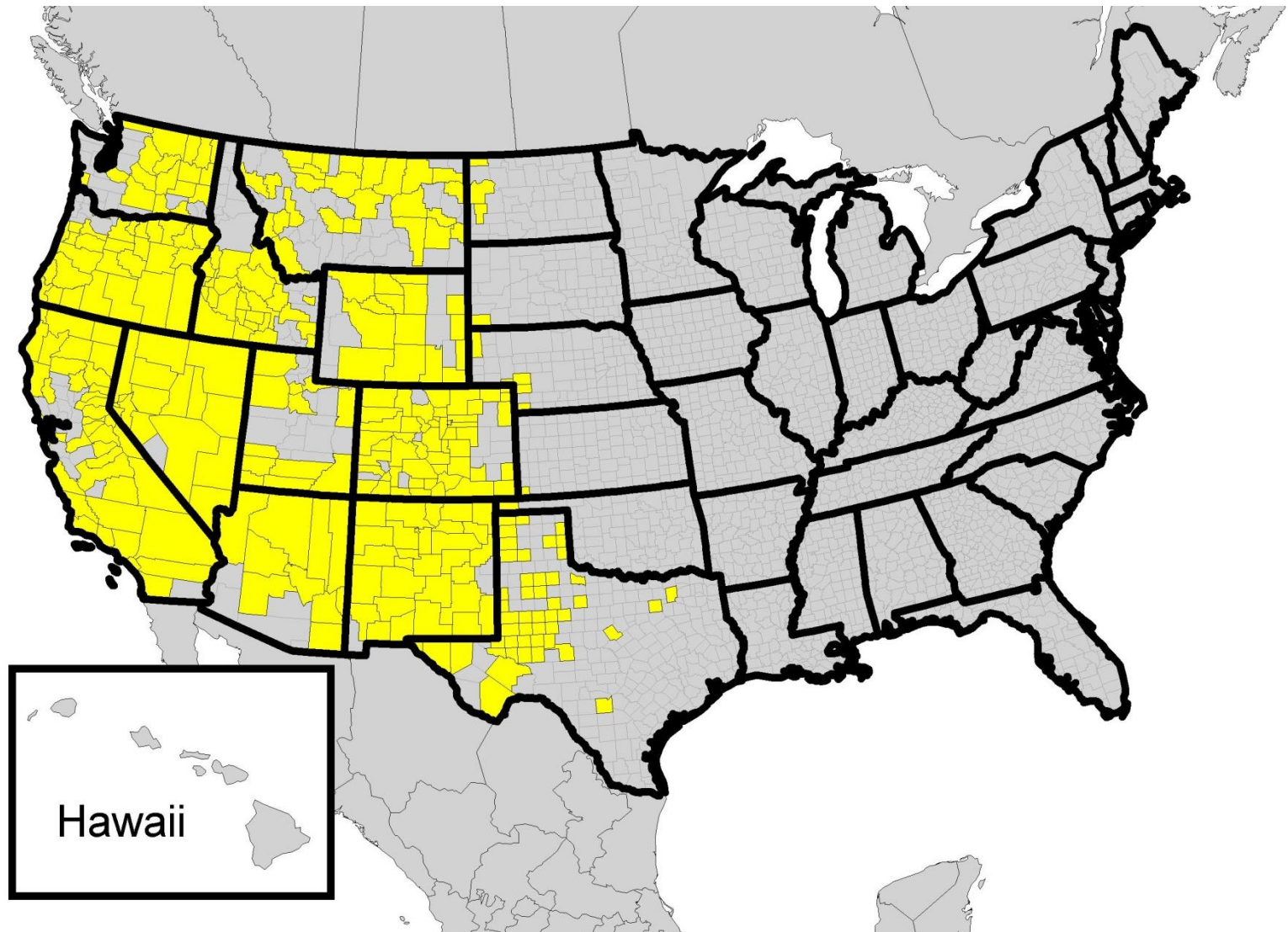
Eskey and Haas, 1940; Pollitzer 1951; Link 1955

Plague can establish in native rodents (esp. ground squirrels)



Eskey and Haas, 1940; Pollitzer 1951; Link 1955

Plague is Now Endemic in the Western US

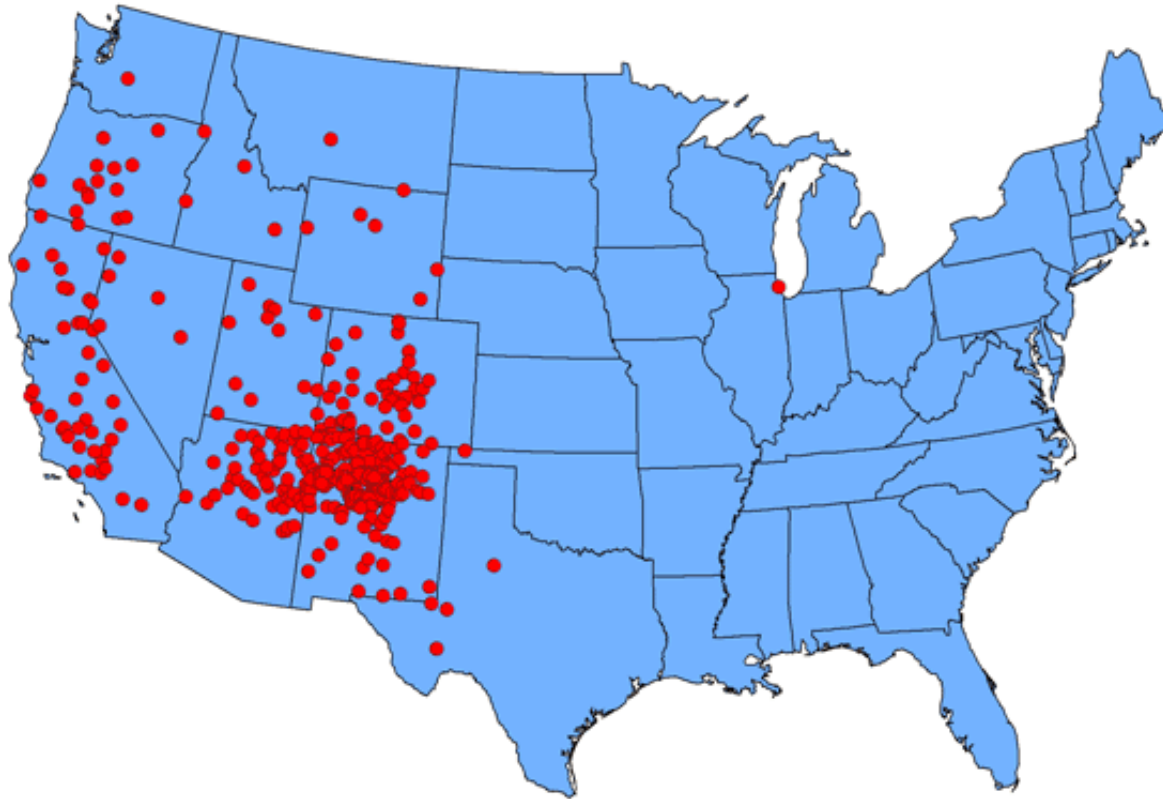


CDC occurrence data for 1970-2000 as compiled by Cully and Williams 2001

Recent Human Plague in the US



Reported cases of human plague--United States, 1970-2012



1 dot placed in county of exposure for each plague case

Source: www.cdc.gov/plague/maps/index.html

Plague in humans

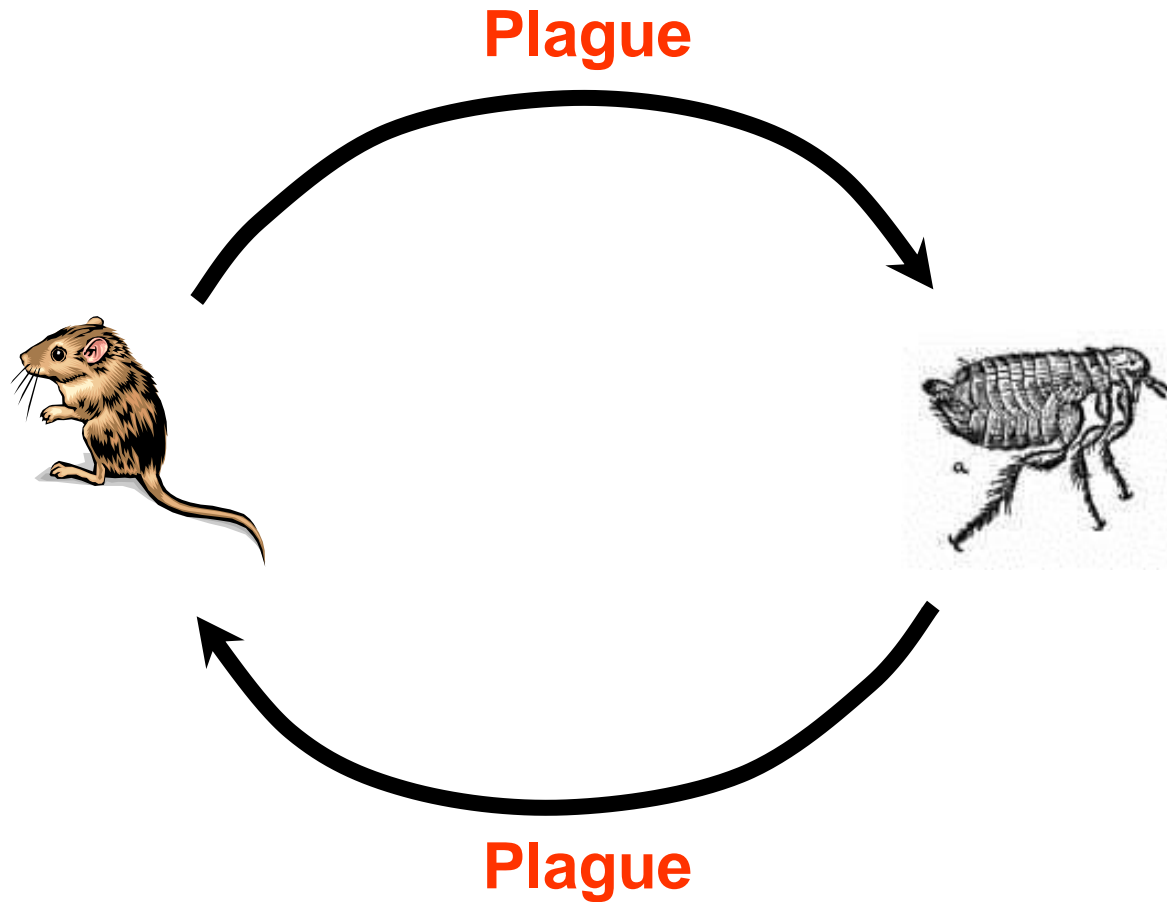


- Rare in US and difficult to diagnose without knowledge of risk factors
- Case example CO2012 (Fox news)
 - While camping in SW Colorado, girl handled a dead squirrel. Also had multiple insect bites.
 - 107°F fever, “doctors were baffled by the cause”
 - Patient survived with antibiotics
- Antibiotic resistance is a concern
 - *Y. pestis* strain with resistance to multiple antibiotics found in Madagascar (Galimand et al. 2006; Welch et al. 2007)

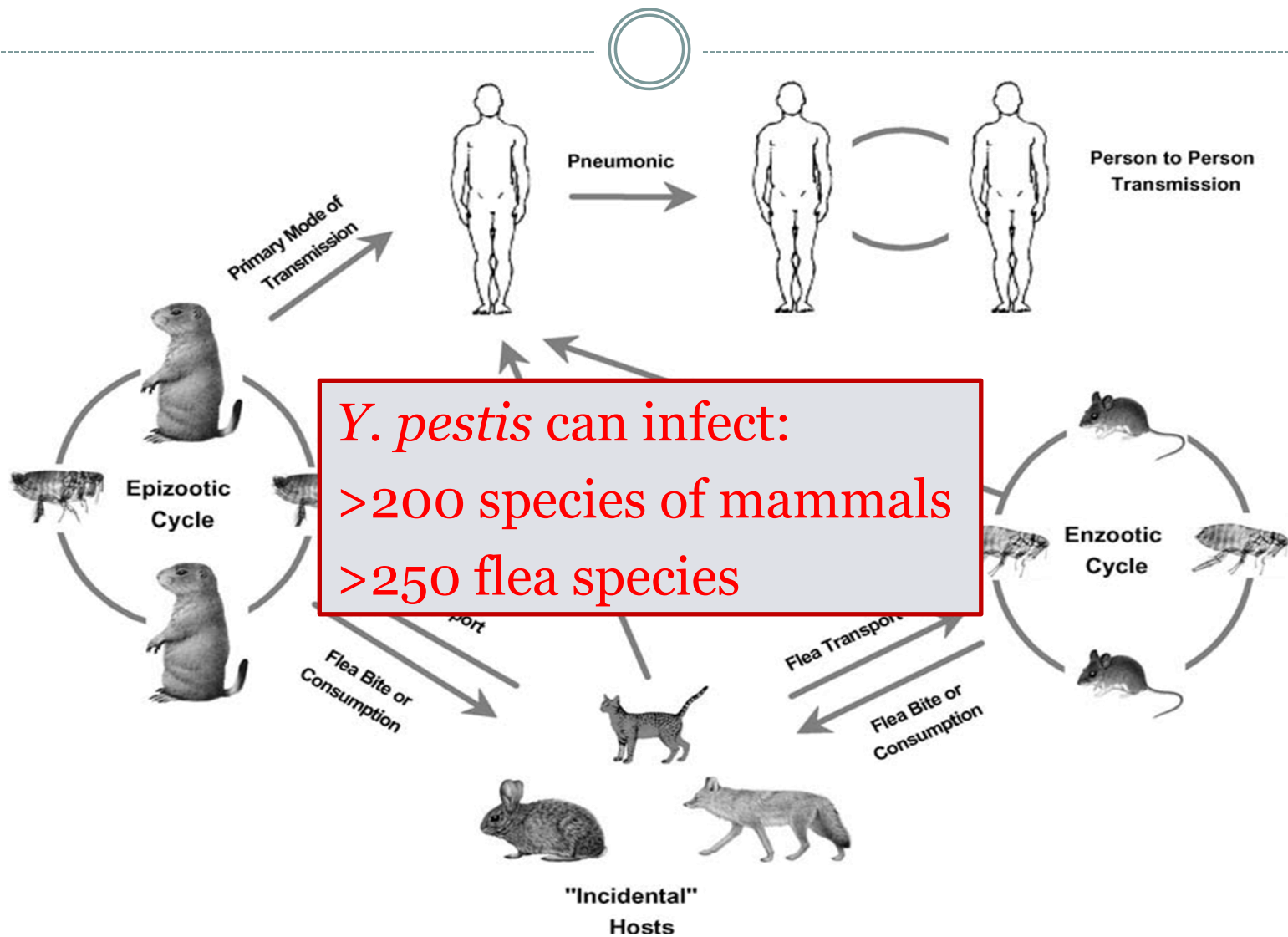


www.foxnews.com/health/2012/09/05/colorado-girl-recovering-from-bubonic-plague/

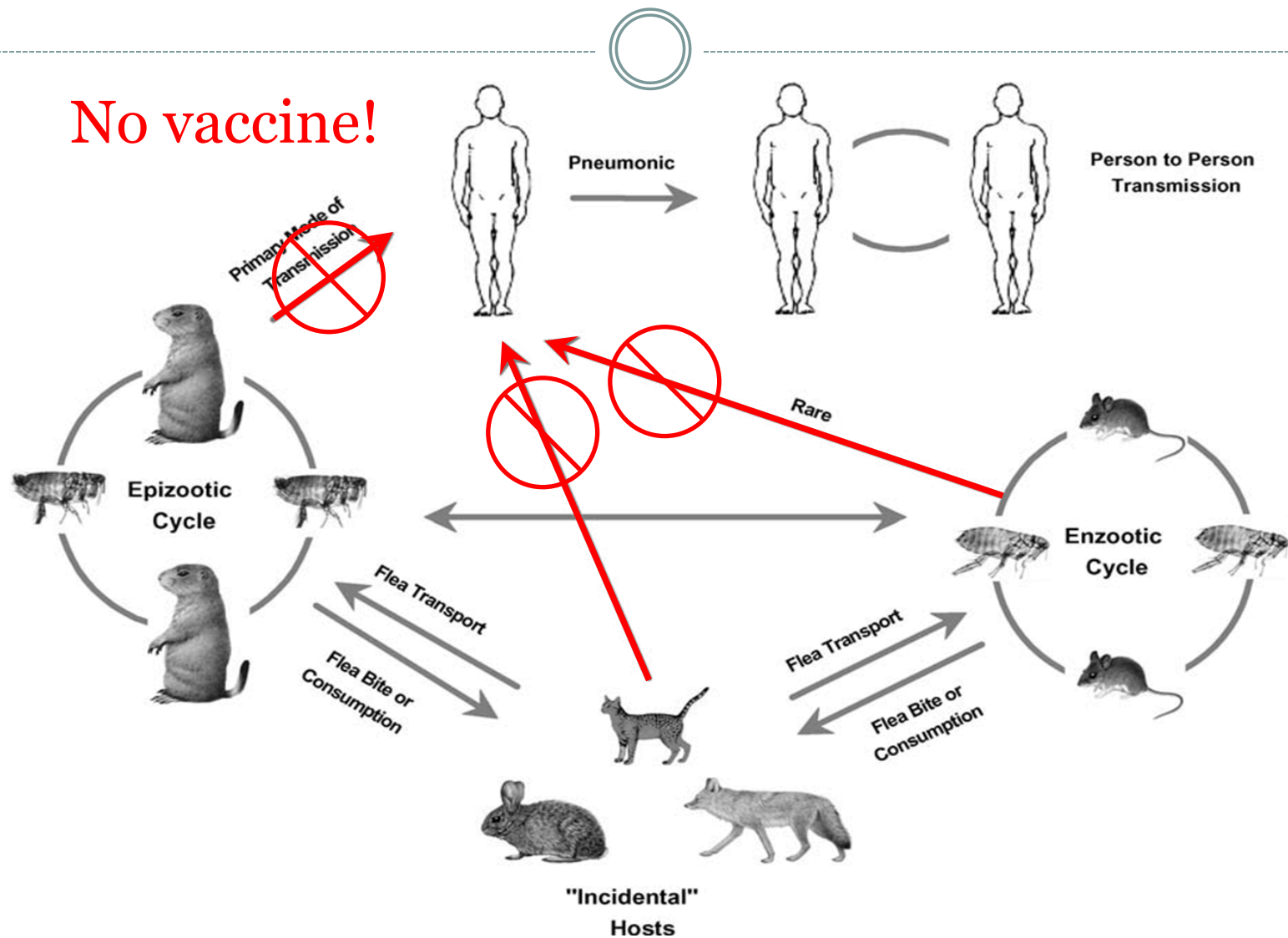
Basic Plague Ecology: a disease of rodents and fleas

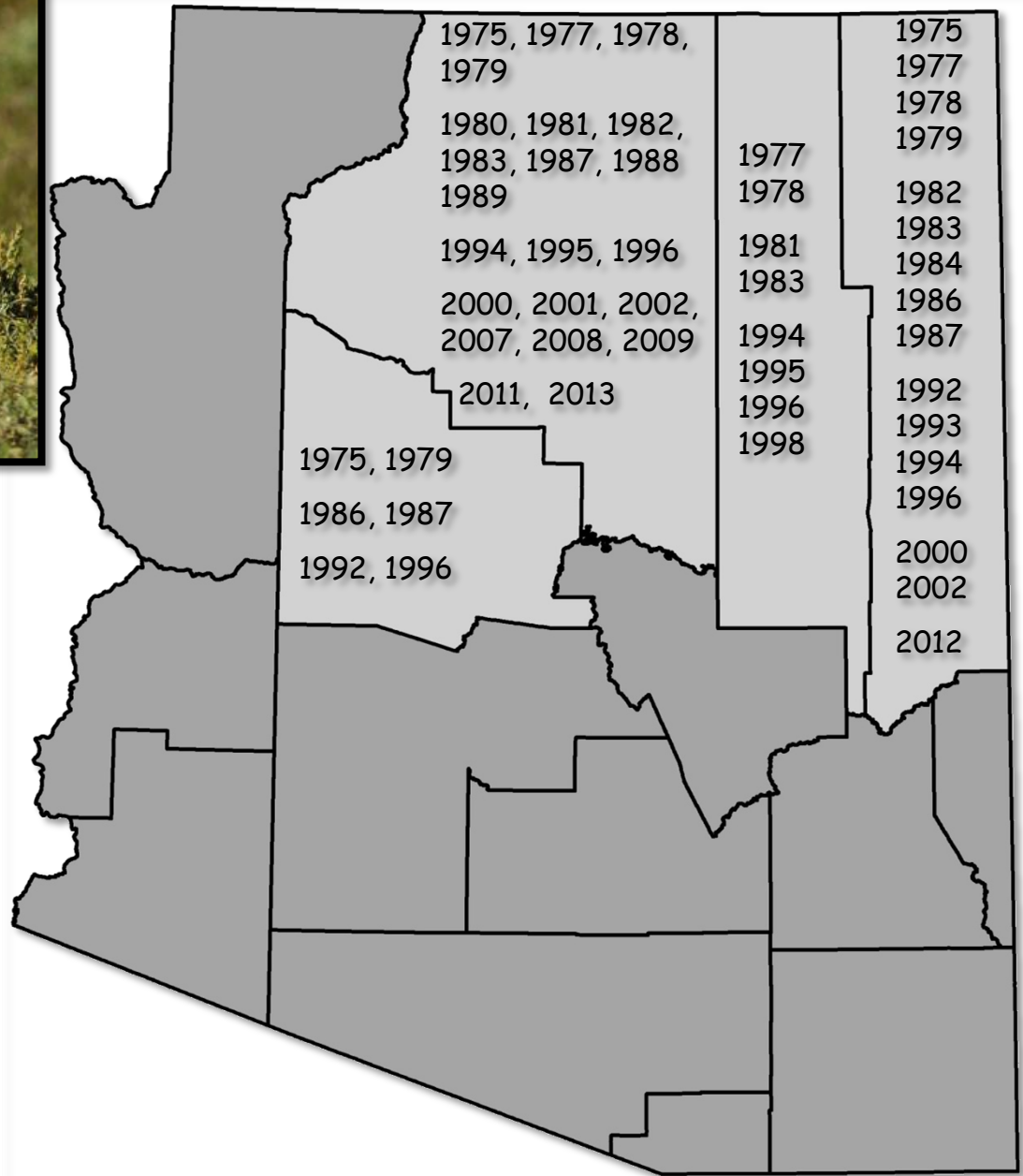
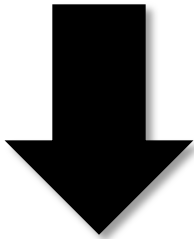


More Complex Plague Ecology



More Complex Plague Ecology







Sentinel species

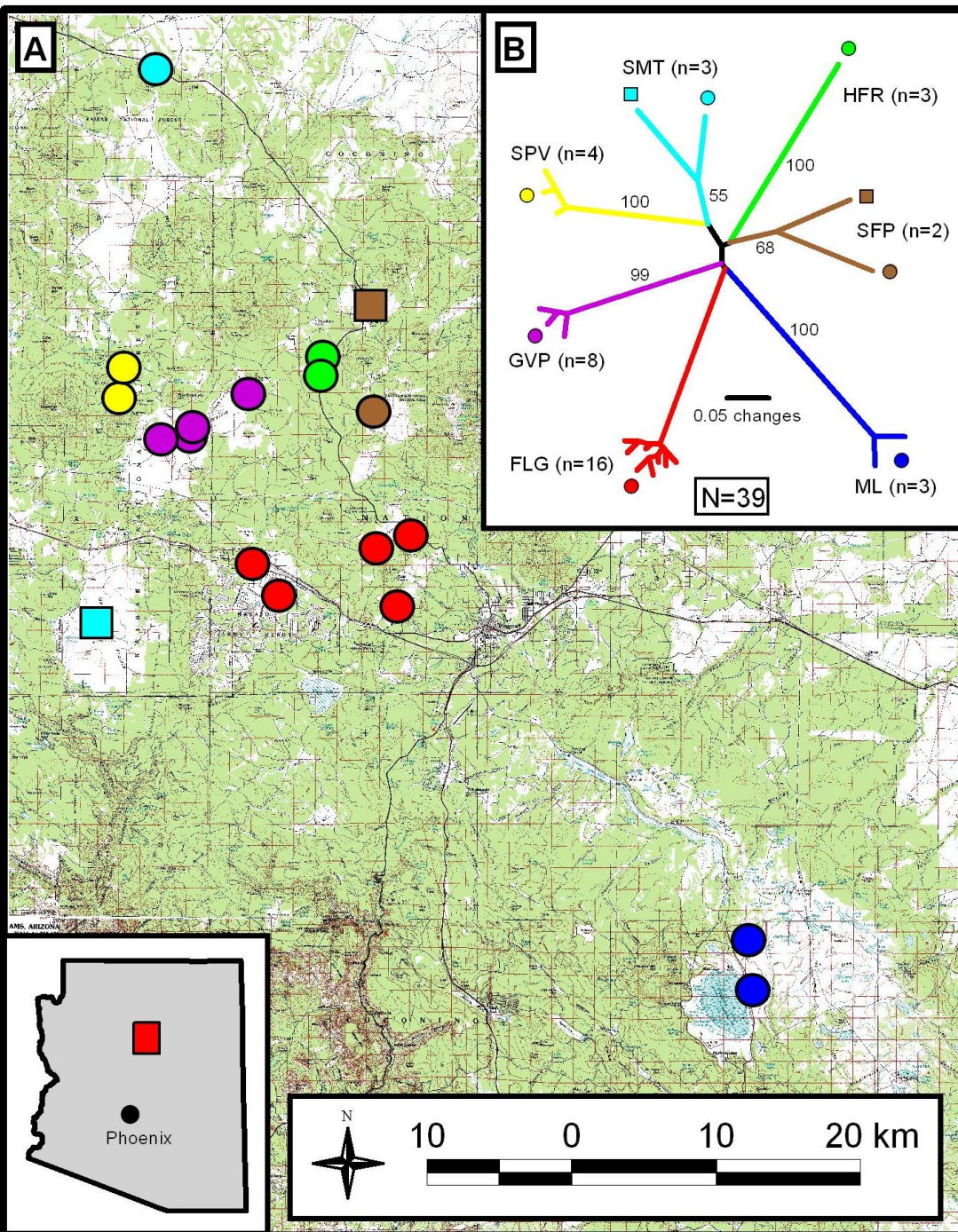
- Monitored by CCHD



Photos: Katy Parise,
Dave Wagner



See Girard and Wagner *et al.* 2004. PNAS 101:8408-8413.



Insights from genetics

- 2001 epizootic in Flagstaff area – sampled fleas from prairie dog burrows
- Plague is widespread in the environment
- Multiple introductions from plague reservoir

Fig. 2. Girard and Wagner *et al.* 2004

Flea monitoring in northern AZ



- MGGen works with state and county health departments to screen fleas for *Y. pestis*.
 - DNA assay using PCR (polymerase chain reaction)
- Long-time collaboration with Coconino Co Health Dept.
 - Marlene Gaither, Hugh Murray, and team – Thank You!
- Field sampling in short window before application of insecticide to burrows
 - NAU samples as many fleas as possible without interfering with flea control

Flea control with Delta dust (deltamethrin)



- Dusting prairie dog burrows near human communities (Flagstaff)
- Flea control increases survival of 3 prairie dog species in plague-endemic areas (Biggins et al. 2010 Vector-Borne and Zoonotic Diseases)

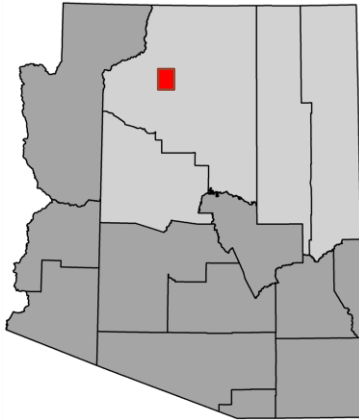


Black-footed ferret

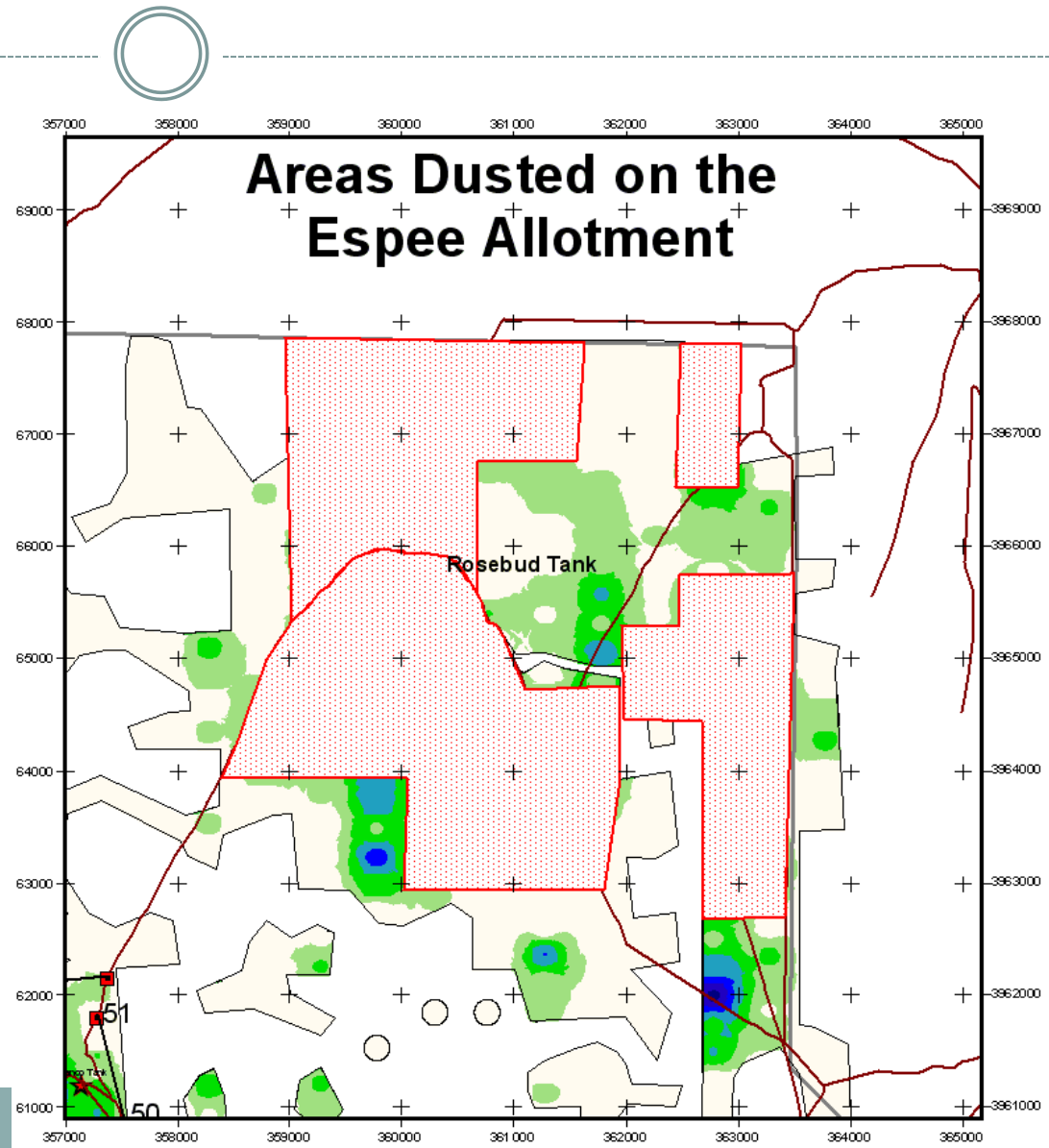


Photo: Charlene Bessen

Flea dusting at Espee Black-footed ferret site



- Successful insecticidal treatment in May-June 2009 (protected prairie dogs inside **red areas**)
- Non-treated areas (**blue/green**) inactive by August 2009
- We cultured *Y. pestis* from fleas sampled outside of protected areas



Alternative control method: Oral vaccines

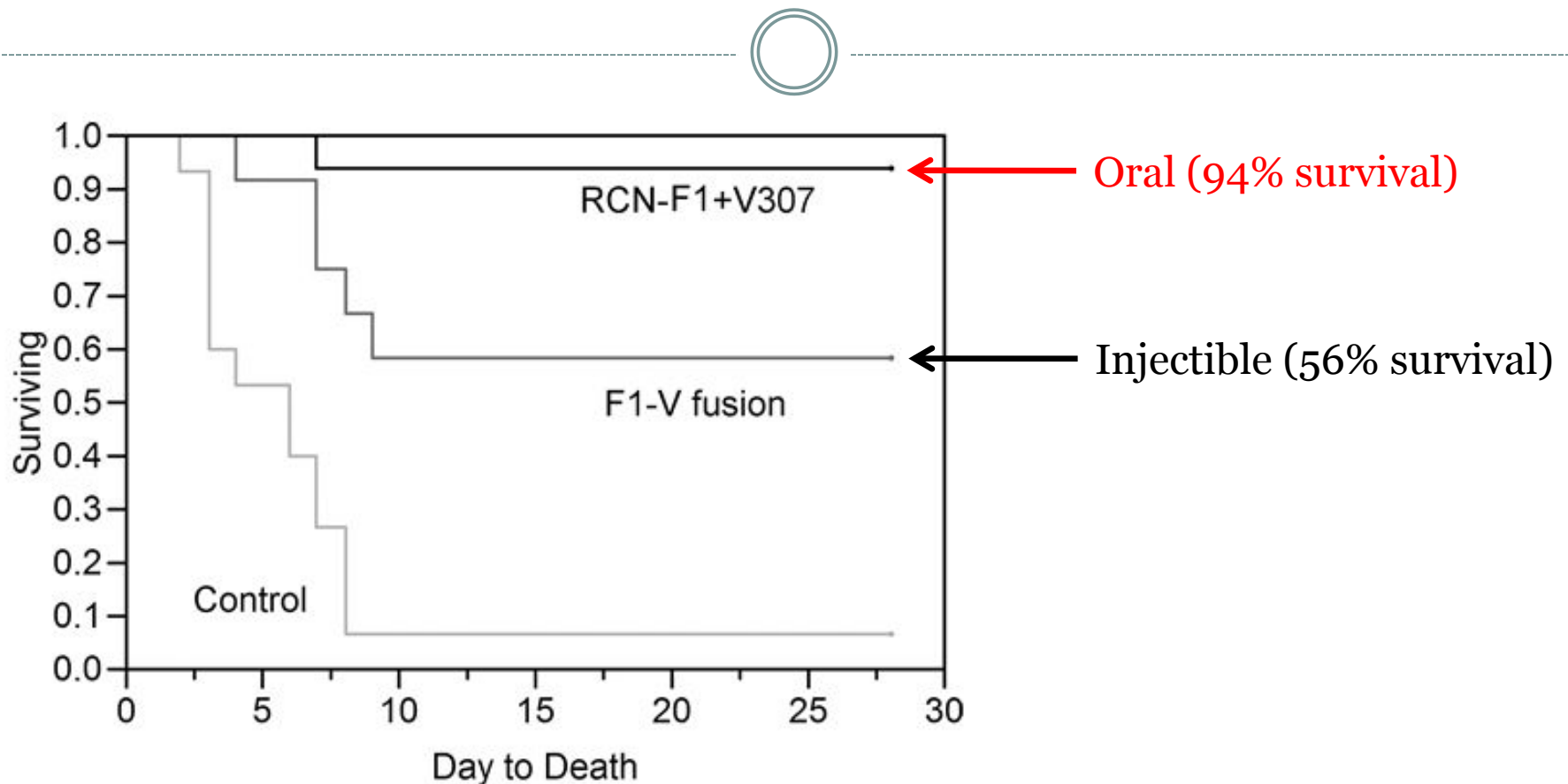
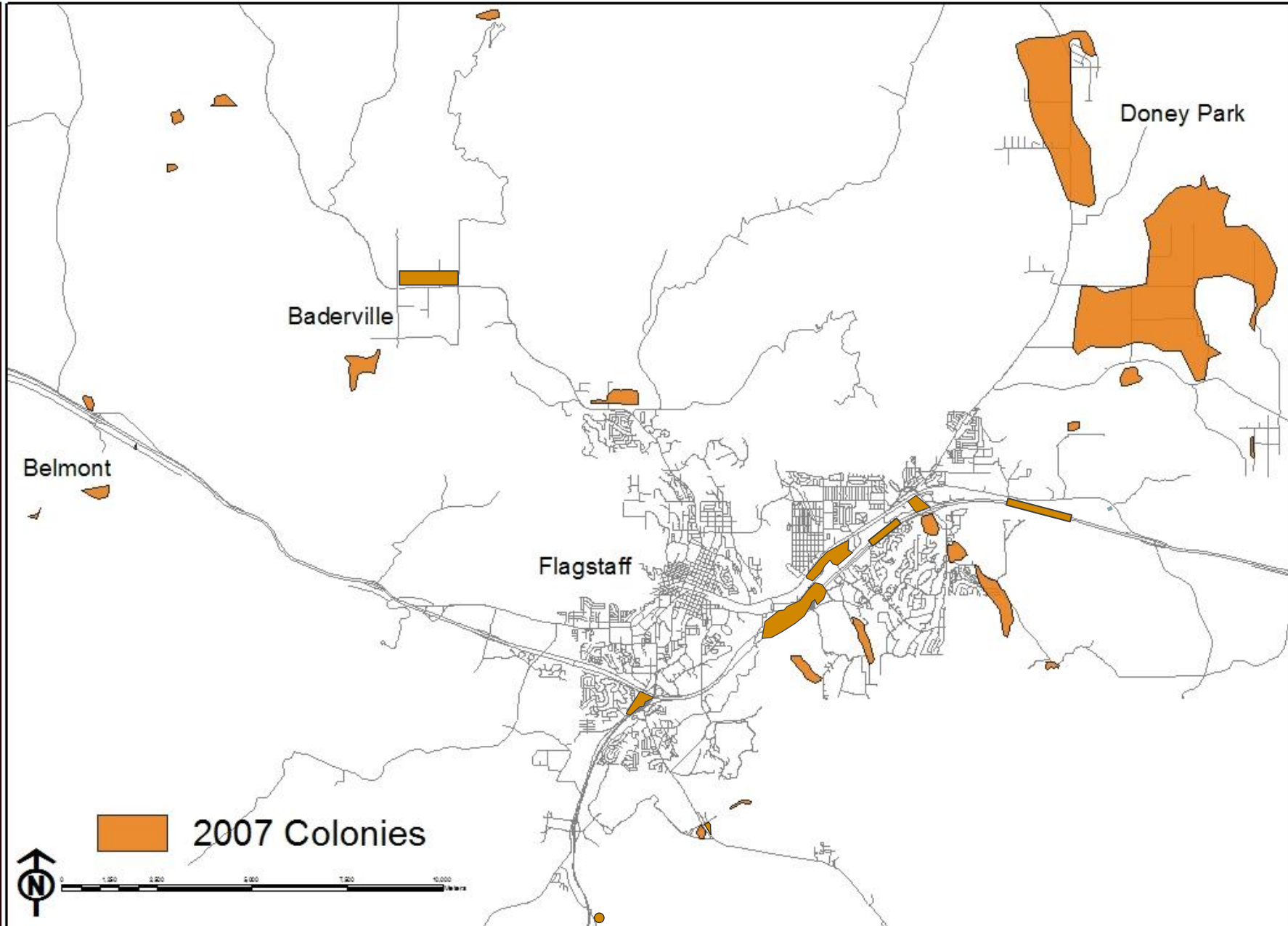


Fig. 2 from Rocke et al. 2010. Vector-Borne and Zoonotic Diseases.

- Edible vaccine for *Y. pestis* now in field trials for prairie dogs (Tripp et al. 2014. J Wild Dis)

Gunnison's Prairie Dog Colonies - Flagstaff, AZ



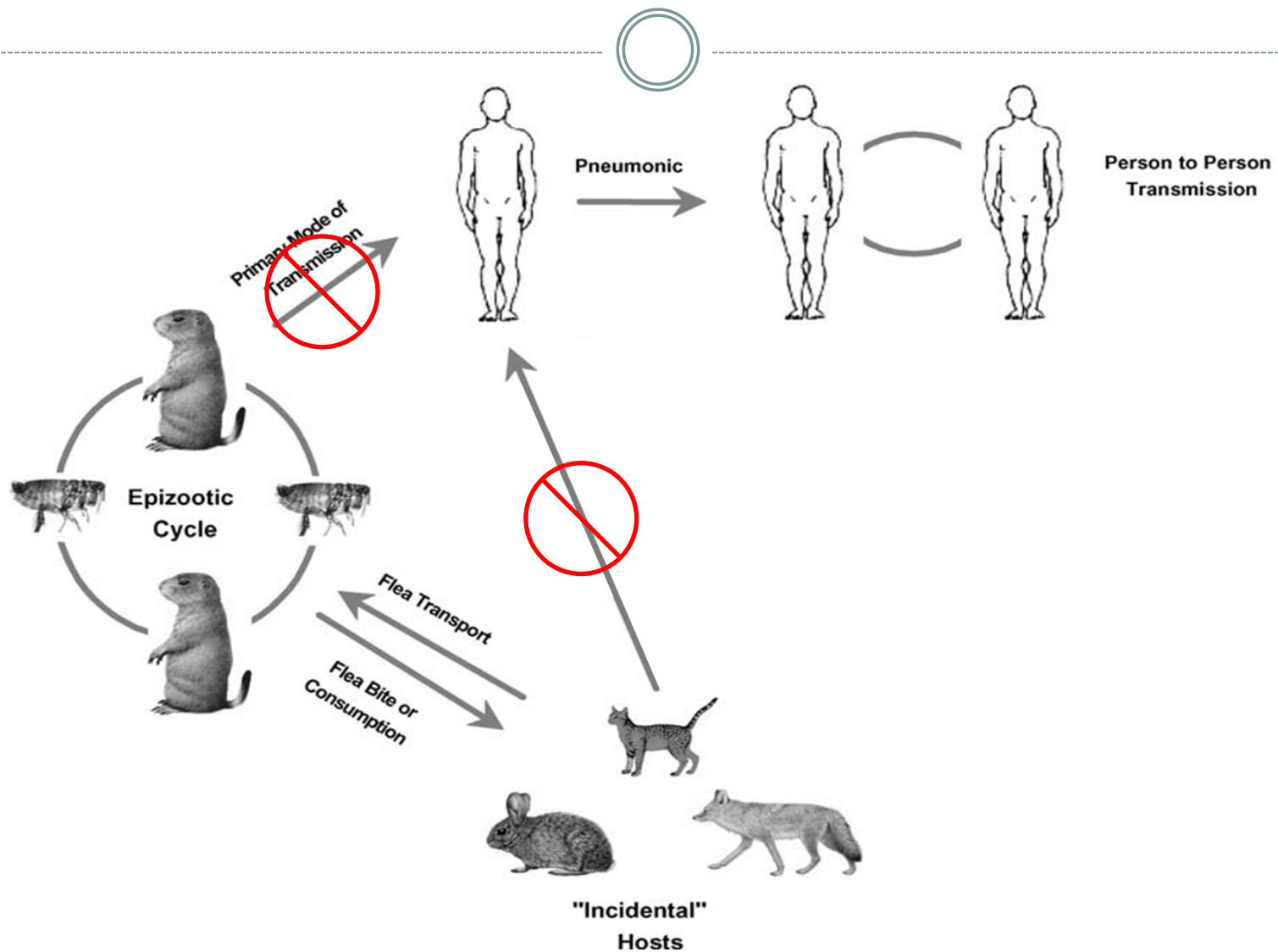
Map by Habitat Harmony, Inc. of Flagstaff

Preventing transmission of *Y. pestis* to humans

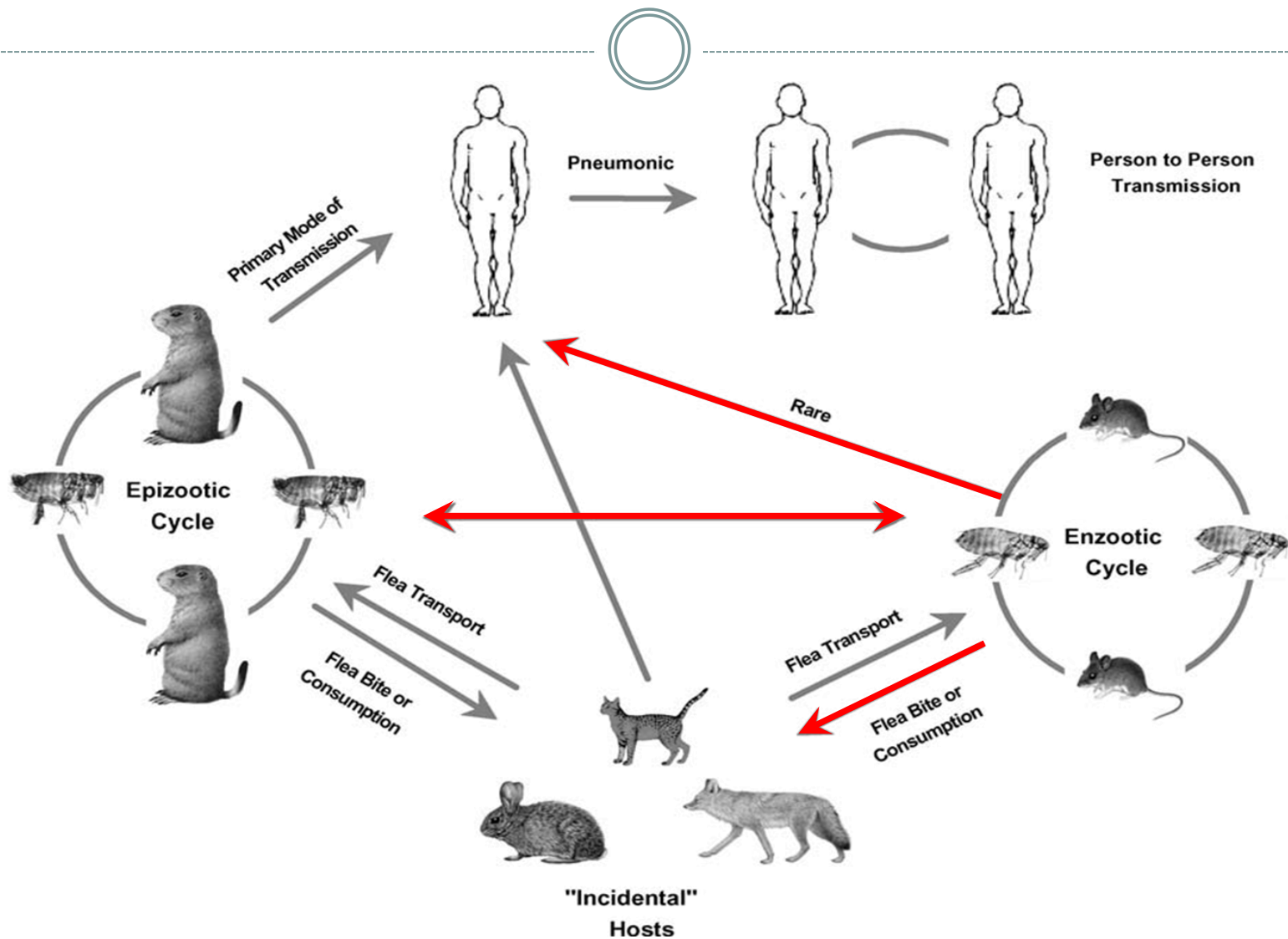


- Use of sentinel species (prairie dogs) and fleas to detect plague
- Vector control (dusting for fleas)
- Education in rural and urban communities
 - Arizona Dept. of Health Services
(<http://www.azdhs.gov/phs/oids/vector/plague/index.htm>)
 - Treat pets for fleas; understand the risk of pets acquiring plague or fleas from wild animals
 - Risk associated with human activity near rodent burrows & nests
 - Risk associated with handling/hunting wild animals (prairie dogs, coyotes, rabbits)

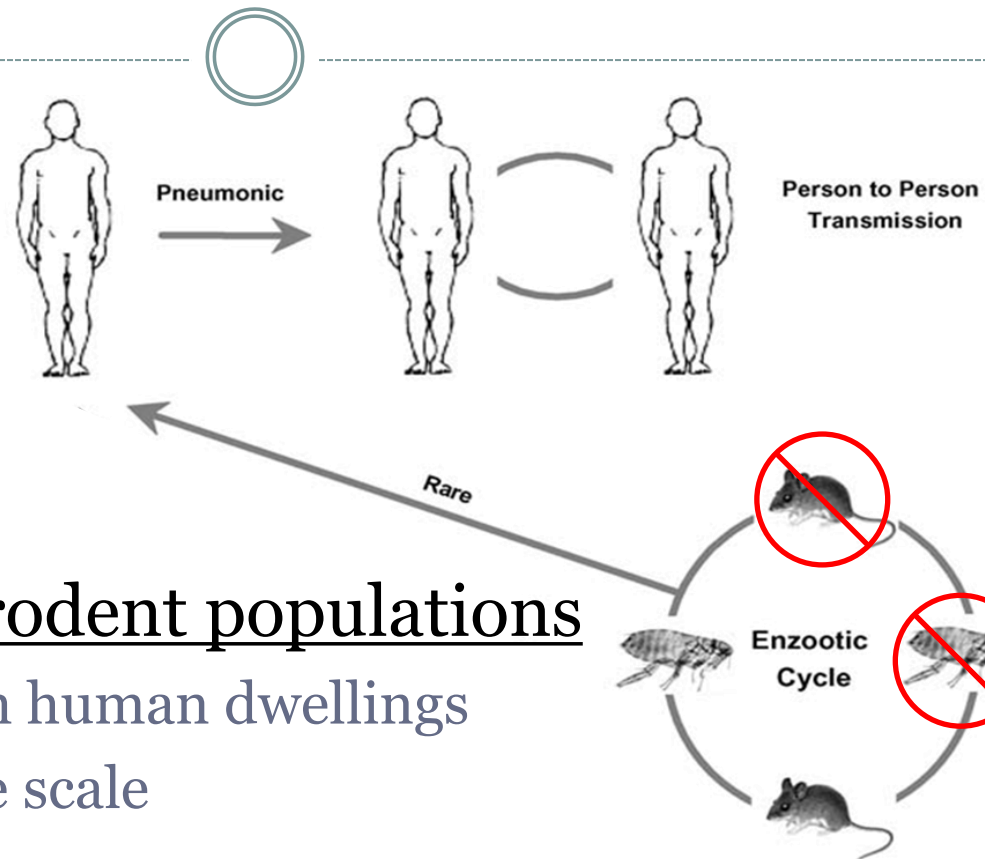
Current methods of plague control target incidental hosts



Is it possible to intervene with plague at its ultimate source?



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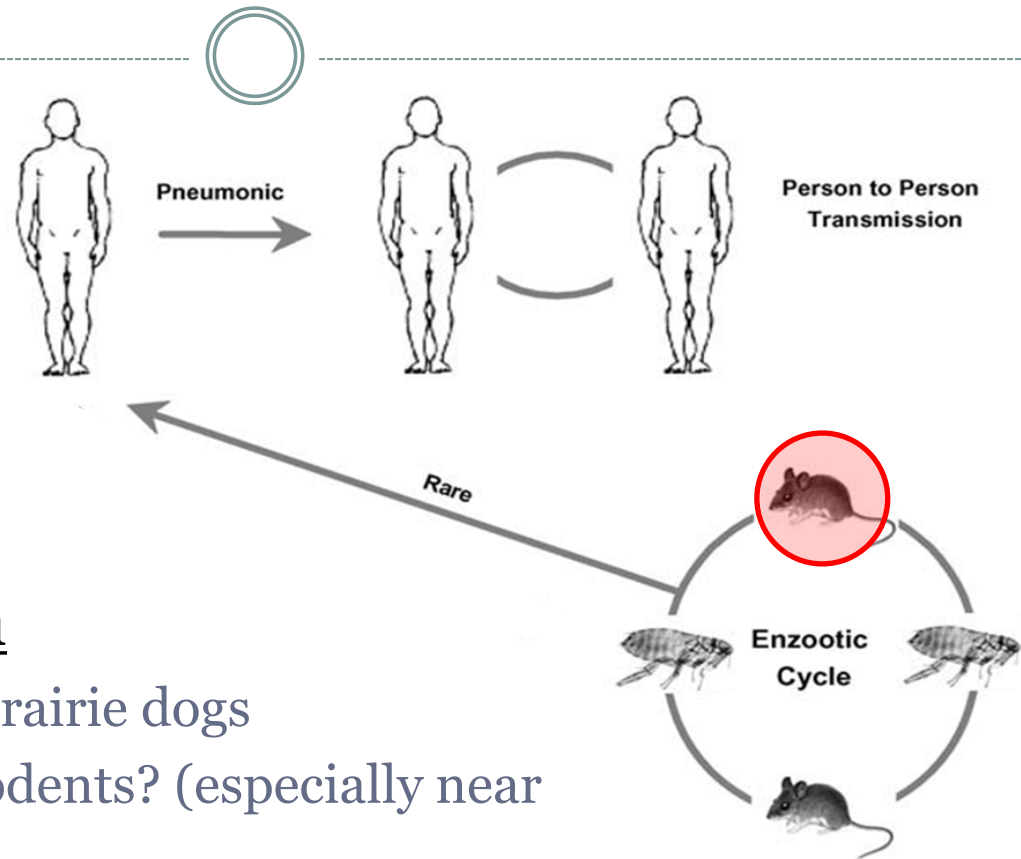
- Control/eradicate rodent populations

- Remove rodents from human dwellings
- Not feasible at a large scale

- Control flea populations?

- Not feasible for most rodent species
- Frequent use could lead to resistant flea populations

Is it possible to intervene with plague at its ultimate source?



- Rodent vaccination

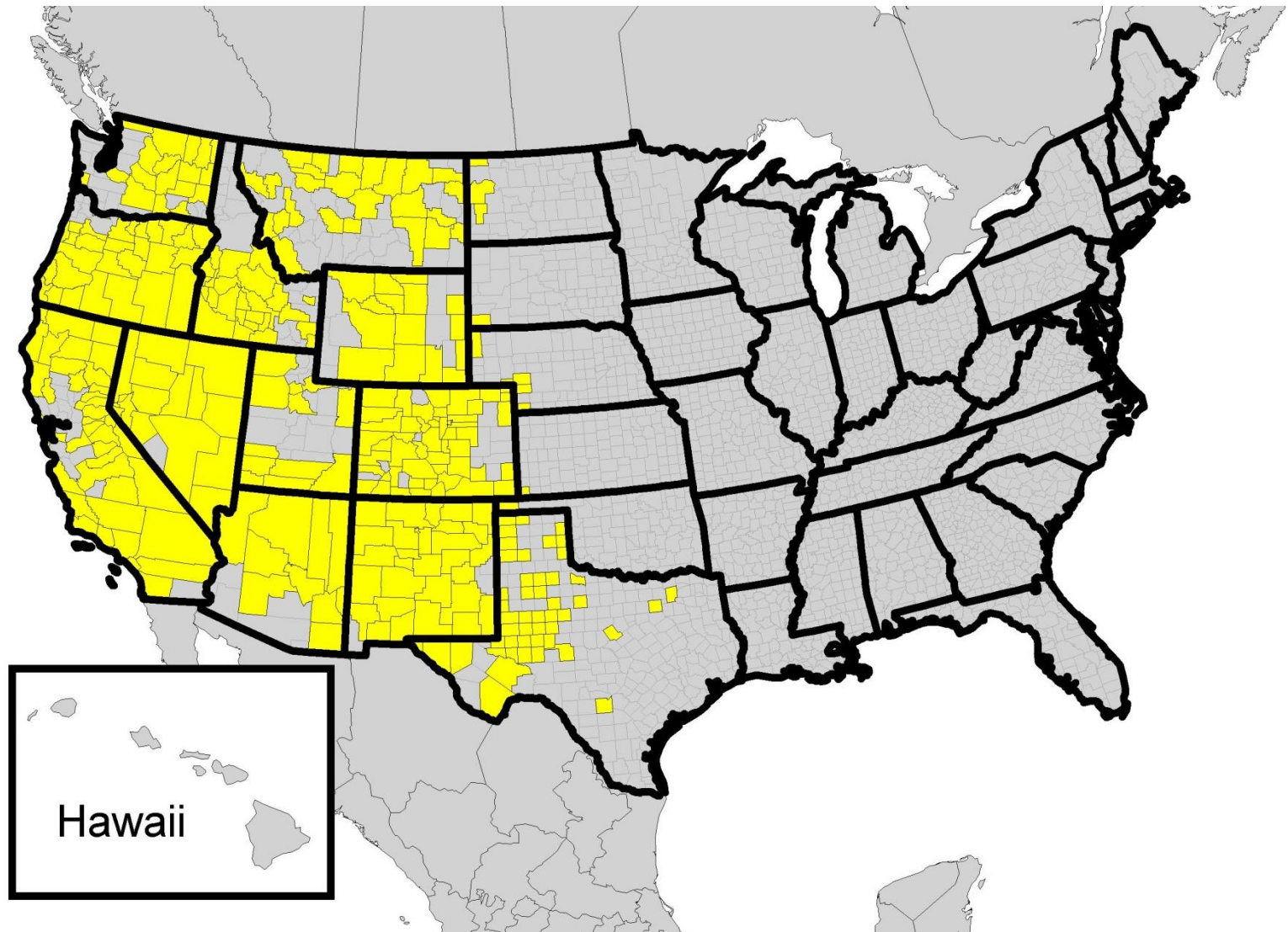
- Oral vaccine tested in prairie dogs
- Possible to treat wild rodents? (especially near human dwellings)
- Our collaborators at ASU (Dr. Roy Curtiss and Dr. Wei Sun) are developing an oral plague vaccine for laboratory mice

Vaccination would be targeted at a local scale (not regional)

- Short timeframes



Plague likely to remain endemic, but it is possible to reduce the threat of transmission to humans



Conclusions and Take Home



- Humans have dispersed *Y. pestis* globally, and it is now endemic in the western U.S.
- *Y. pestis* cycles in native flea and rodent reservoirs
- Currently, plague control targets incidental hosts
 - Near human dwellings
 - Black-footed ferret sites
- Flea treatment is a widely used control method
- Intervention of plague at its ultimate source would require an alternative strategy:
 - Vaccinating small rodents (possible?)

Acknowledgements



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